Lapindo Mud Pollution Effects on Total Fe and Pb content of Corn (*Zea Mays* L.)

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ABSTRACT

The study was conducted with the aim to study how much influence the Lapindo mud contamination in total Fe and total Pb corn crops on the farm. The research model is designed as factorial with the proportion of mud as the first factor with 3 levels of 50%, 33% and 25%, the second factor; organic matter with a dose of 0, 30 and 50 ton / ha; The third factor; the addition of gypsum (CaS042H2O) with doses of 0, 4 and 8 tons / ha, repeated 3 times to plant corn indicator.

Parameters observed plant height, total plant fresh weight, total plant dry weight, total Fe, and Total Pb at harvest (5 Week After Planting/WAP).

The measurement results showed that a decrease in the mud did not affect the levels of total chlorine and total Pb real effect on the corn crop. Padaa lowest levels of total Fe Average 19:56 ppm (upper limit of the critical shortage of Fe), and total average 0:33 Pb ppm (Pb plant under normal limit). Mud-soil interaction by organic matter and gypsum significant effect on the total Fe and Pb is significant in the total corn crop. At the time of harvest corn 5 MST, a decrease in sludge are also a very significant effect on the total wet weight and total plant dry weight, but had no effect on plant height. The average total wet weight of 100.23 g corn plant, total plant dry weight of 38.43 g and an average plant height 77.56 cm.

Key Words: Lapindo Mud, Total Fe, Total Pb and Maize

INTRODUCTION

Terms, 'Contamination' refers to the entry or introduction of solids / liquids or other components to the surface or into the root zone. Concentrated soil solution containing dissolved materials from a variety of different types and characteristics of the area into the root zone of plants and alter the characteristics and behavior of the soil. Lapindo Mud immerse the land in 16 villages approximately 600 hectares including sugarcane and paddy farmland area of 198 ha. The land was once productive land is categorized as class I for agriculture. However, due to contaminated fluid changed drastically Lapindo mud into marginal land that can not be made to any agricultural cultivation. Not to mention the impact of methane gas that settles along with the compaction of mud (McCauley and Jones, 2005).

Solid pollutants are considered entry into the root zone of plants is mud with the physical characteristics specific gravity ranging from 1,25 to 2,35 g,cm^{-3}, 34% clay content, dust 39%, 27% sand (Alvin, Barlah, Bambang (2013). characteristics of chemistry reported by Ratna and Kristanti (2013) is Pb, Hg, Sn, Ar. Whereas Rina, Setyo, Sutisna, Istanto, Sumardjo (2007), with a rate of of 6 -11 ppm As and Cr 81,8 - 97,5 ppm (and gas-methane. Test the soil chemistry at the Lapindo mud fluid obtained K 1,5 to 1,8%, 1,4% Ca, Mg 0,7%, Al 0,6%, Fe 64 %, Na 1,4 to 3,6%. (Rina, et al, 2007). further Alvin et al. (2013) showed that the pH ranges from 6,6 to 7, CEC of 3,89 to 35,42 me / 100g , amounting to 0,19 to 0,34 ppp Pb, Cu of from 0,19 to 0,85 ppm.

Problems that arise from the Lapindo mud characteristics are so complex that includes physical and socioeconomic conditions in the disaster area. Agricultural land which was originally a source of livelihood of local communities for the cultivation of food crops and vegetables become dysfunctional due to contaminated seepage and sludge.

This research was conducted with the aim to provide preliminary information on the impact of pollution on the Lapindo mud corn crop characteristics. To that tested the tolerance of maize in a planting medium models by combining the mud-soil given organic matter and gypsum.

MATERIALS AND METHODS

The study was conducted from May 2016 to the month of December 2016 in the greenhouse and laboratory Land Resources Faculty of Agriculture, National Development University "Veteran" East Java, Surabaya. The experiment was modeled completely randomized design factorial first factor: the proportion Mud-soil with three portions, namely a) Mud (50%), b) Lumpur (33%) and c) Mud (25%). The second factor is the organic material (OM) with three levels: a) 0 ton.ha^{-1}, b) 30 ton.ha^{-1}, c) 50 ton.ha^{-1}, Whereas Factor III are Gypsum with three levels, namely a) 0 ton.ha^{-1}, b) 4 ton.ha^{-1} c) 8 ton.ha^{-1}, each treatment was repeated 3 times, combination treatment is 27 treatment.

Land of the Lapindo mudflow wind dried and then sieved to qualify sieve 2 mm mixed with mineral soil dry air passes a 2 mm sieve. The treatment combination of air set dry weight equivalent to 5 kg, as well as manure and gypsum equivalent to each dose. Each treatment was made in conditions of field capacity by adding water evenly as much as 1300 ml. Then incubated for 3 weeks in a sealed polybag.

After 3 weeks of planting corn seeds with 3 seeds per polybag. Observations tinggti plant conducted from 1 week old plants after planting (WAP), to 5 WAP. Measurement of wet weight, dry weight of plants (shoot) and root (root) was done after harvest (age 5 WAP). Chemical plant parameters include total Fe and total Pb.

Data obtained from laboratory measurements analyzed according to the model variants of study designs that are applied to determine the differences among the treatments do LSD (List Square Difference). Model guess that is used for analysis of variance is:

$$Y_{ijkl} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + (\alpha\beta)_{jk} + \varepsilon_{ijkl}$$

While for determine the influence of treatment on the parameters expected to do correlation and regression. Parameter guess that is used is as follows:

$$Y_{ij} = \mu + \beta (X_{ij} - X) + \varepsilon_{ij}$$

Analysis of the data some experimental results:

a. Analysis of variance (ANOVA).
b. LSD (List Square Difference).
c. Correlation and regression parameters between the treatment of soil and crops

RESULTS AND DISCUSSION

1. Total Ferrum (ppm) Plants

Ferrum is one of the essential nutrients that are necessary in the formation krorofil, preparation of proteins and enzymes. The treatment combination of mud-soil, manure and gypsum has not shown a significant effect on the total Fe corn. Total Fe plant L3B2G2 the lowest at 8.04 ppm, the highest in the L3B0G0 28.10 ppm, and an average of 19.56 ppm Fe. The interaction of three factors on the total Fe plant are presented in Table 1. The figures in the table below the total range of Fe in the plant between 25-500 ppm Fe.

Analysis of variance sludge factor is not real effect on total Fe plant. This is due to the increase in the portion of the mud that add dissolved Fe soil. The increase in Fe soil solution will increase the amount of ferrous ions are absorbed by plants (Cauley, Jones and Jaconsen (2009). Ion ferro-bound clay or organic matter will increase with increasing pH value to 9,0. Benton (2012).

Table 1. Combination Treatment Portion Mud, Organic Materials and Gypsum on Total Fe Plant

No	Combination Treatment	Total Fe (ppm) Plants*)	
1	L1B0G0	20.42	e
2	L1B1G1	21.88	gf
3	L1B2G2	16.98	b
4	L2B0G0	21.88	f
5	L2B1G1	18.20	c
6	L2B2G2	21.88	g
7	L3B0G0	20.42	fe
8	L3B1G1	19.05	d
9	L3B2G2	14.79	a
	LSD 1% =	0.40	

*) numbers accompanied by the same letter are not shows significantly different

Figure 1 shows the increase in total Fe crop of 5,965 units, with a correlation (r = 0,373) due to the increase in the portion of the mud. The increase in total Fe plants as well as the interaction of these three factors influence treatment (Figure 2), although individually the three factors are not significant on increasing the total Fe plant.

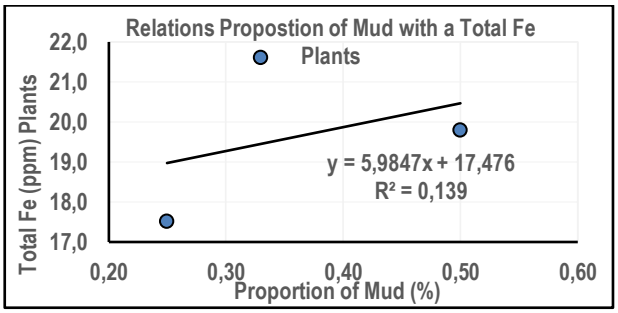

Figure 1. Proportion of Mud-Soil Relationships with Total Ferrum Maize Age 5 Weeks After Planting (5 WAP)

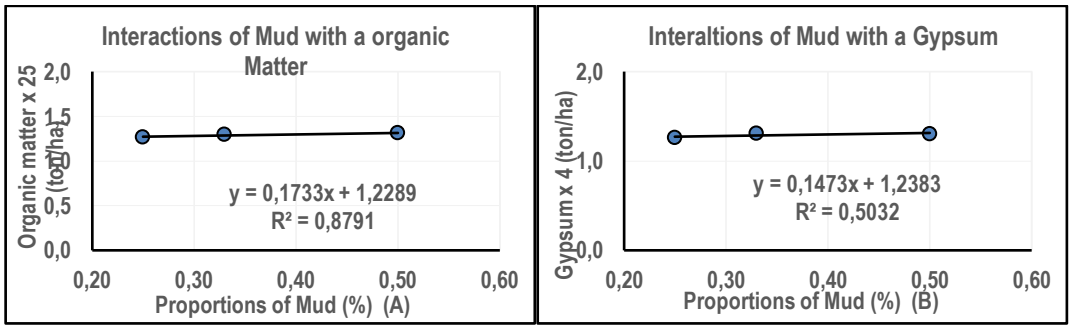

Figure 2. The proportion Mud interaction with Organic Materials and Gypsum in the Improvement of Maize Total Ferrum Age 5 WAP.

Figure 2 above shows the interaction of factors sludge (L) with organic material (B) and the mud factor (L) with gibsum (G). The addition proportion of silt and organic material one unit, total Fe plants in a very real increase amounted to 0,173 uni with a correlation coefficient of r = 0,94 (Fig. A), as well as the addition of mud and gypsum portion of the total Fe plant unit increased significantly by 0,147 units with a correlation coefficient of r = 0,71 (Fig. B).

2. Total Pb (ppm) Plants

Lead (Pb) is not among the soil nutrient. The existence of these elements in the soil solution and plants often makes the body of toxins. Pb 2+ cations in the solution if the amount is excessive soil will inhibit absorption of other nutrient cations.

Results of analysis of variance showed that the total Pb content of plants by an average of 0.33 ppm was within normal limits set by the Research and Development Department of Agriculture Department of Agriculture (2009) of between 0.2 to 20.0 ppm Pb and still below the threshold set by BPOM and WHO at 0.5 ppm (in Rizka, Fida, and Yuliani, 2015). Total Pb lowest at treatment plants L3B0G0 (0.19 ppm Pb), the highest in the treatment L1B2G2 (0.51 ppm Pb). Treatment of mud-soil proportion of the total plant Pb are presented in Table 2.

Table 2. Proportion Mud-Land on Total Pb Maize Age 5 WAP

Proportion Mud	Average Total Pb (ppm) plants*)
L1 (50% Mud)	0,367 b
L2 (33% Mud)	0,351 b
L3 (25% Mud)	0,278 a
BNT 5% =	0,065

*) numbers accompanied by the same letter are not shows significantly different

The table shows that the addition of sludge portion Significantly increasing total plant Pb, Although not Significantly correlated (r = 0,40). The addition of mud portion of the unit will increase of total plant Pb of 0,143 units (Figure 3). The increase is in total plant Pb when penen still much lower than that Reported Anonymous (2009) in the Lapindo mud at 50 ppm.

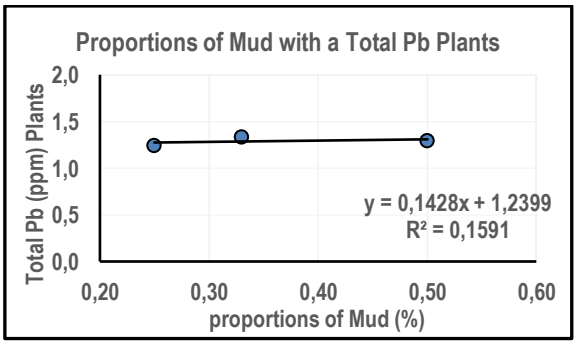

Figure 3. Proportion of Mud-Soil Relationships with Total .pdb Maize Age 5 WAP

The interaction factor treatment sludge with organic material and silt factor with gypsum indicate an increase in total plant Pb (Table 3). Total Pb plants due to interaction proportion of silt and organic material between 0,22 ppm Pb (L3B0) – 0,44 ppm Pb (L1B2), and interaction with gypsum sludge proportion of 0,25 ppm Pb (L3G1) – 0,41 ppm Pb (L1G2).

Table 3. Proportion Mud interaction with organic materials and Gypsum on Total Pb Plant Age 5 WAP.

Interaction proportion Mud-Organic Materials		Interaksi Proporsi Lumpur-Gipsum	
Treatment	Total Pb (ppm) Plants*)	Treatment	Total Pb (ppm) Plants*)
L1B0	0,330 b	L1G0	0,338 a
L1B1	0,332 b	L1G1	0,354 ba
L1B2	0,439 c	L1G2	0,410 c
L2B0	0,378 b	L2G0	0,354 b
L2B1	0,307 a	L2G1	0,387 cb
L2B2	0,367 b	L2G2	0,312 a
L3B0	0,222 a	L3G0	0,276 a
L3B1	0,315 ba	L3G1	0,251 a
L3B2	0,297 a	L3G2	0,308 a
LSD 1% =	0,087	LSD 1% =	0,087

*) numbers accompanied by the same letter are not shows significantly different

Table 3 shows that the proportion of interaction sludge with organic material and the proportion of gypsum slurry with a very significant effect on the total deficits improve plant Pb. This increase allegedly Pb adsorbed by clay and organic material released into the soil solution (Tan, 1982) and dissociation sanggaan salt that binds Pb2+ ions (Mulyadi, 2013).

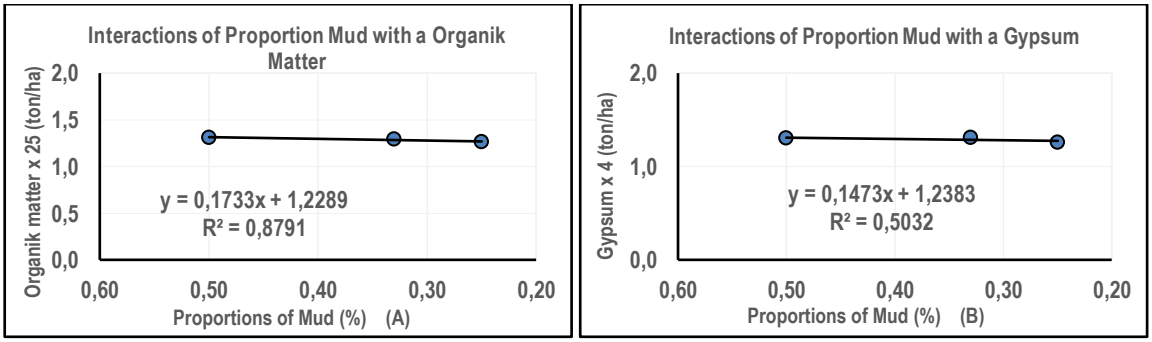

Figure 4. Proportion Mud Interaction with Organic Materials and Gypsum on Decrease Total Plumbum (Pb) Maize Age 5 WAP.

Figure 4 shows the increase in the portion of the mud of the unit, followed by the addition of organic material of the unit (Fig. A) and or the addition of gypsum one unit (Fig. B), will reduce the total Pb plants are very real for 0,173 units with a correlation coefficient of r = 0,94 (Fig. A), and significantly amounting to 0,147 units with a correlation coefficient of r = 0,79 (Fig. B).

3. Plant height and weight.

Utilization of agricultural land that has been contaminated mud Lapindo become increasingly limited, because the contaminants left in the soil such as heavy metals, the addition of cations and anions that alter the balance of sorption and sanggaan ground. Changes in these properties will reduce the choice of commodities that can be cultivated, including food or non-food crops. The growth of corn plants require well drained soil, textured, base saturation <60%, pH 6,8, and soil CEC> 15 me.100^{-1}g (Puslittan, 1993). Currently these requirements difficult to meet for their rembasan and mud flows into agricultural lands which carry contaminants.

Analysis of variance showed the combination treatment of these three factors has no effect on the weight of the plant. Shoot fresh weight average 71,20 g, 144,54 g highest in treatment L3B2G1, 28,84 g lows in L1B1G1. Shoot dry weight average of 23,61 g, 31,90 g highest in treatment L2B0G1, the lowest in treatment L1B1G1 18,06 g. An average of 29,.03 g wet weight root, the highest 48,60 g (L3B2G2), 15,25 Lowest g (L2B1G0). The average weight of 14,82 g of dried root, the highest 24,93 g (L2B0G1), 8,32 lowest g (L1B1G0).

Factors proportion of mud showed significant differences in the weight of the corn crop at harvest Table 4. Factor L3 (25% slurry) showed the highest weight value crops caused by an increase in mineral soil to 75%. The decline reflects a decrease in the portion of the mud mencemar material which is offset by increased capacity refutation of the portion of the mineral soil.

Table 4. Proportion Factor Mud-Soil, Organic Materials and Gypsum on Wet weight, dry weight of plants (shoot), root wet weight, dry weight root (root) Corn crop Age 5 WAP.

Wet weight Shoot*)	
Faktor L	Berat (g)
L1(50%)	46,13 a
L2(33%)	82,60 b
L3(25%)	94,62 cb
LSD 5% =	0,106

Dry weight Shoot*)	
Faktor L	Berat (g)
L1(50%)	20,170 a
L2(33%)	25,085 b
L3(25%)	25,582 cb
LSD 5% =	2,723

Wet weight Root*)	
Faktor L	Berat (g)
L1(50%)	23,50 a
L2(33%)	31,92 b
L3(25%)	32,58 cb
LSD 5% =	0,100

Dry weight Root*)	
Faktor L	Berat (g)
L1(50%)	9,71 a
L2(33%)	18,07 b
L3(25%)	18,58 cb
LSD 5% =	0,060

*) numbers accompanied by the same letter are not shows significantly different

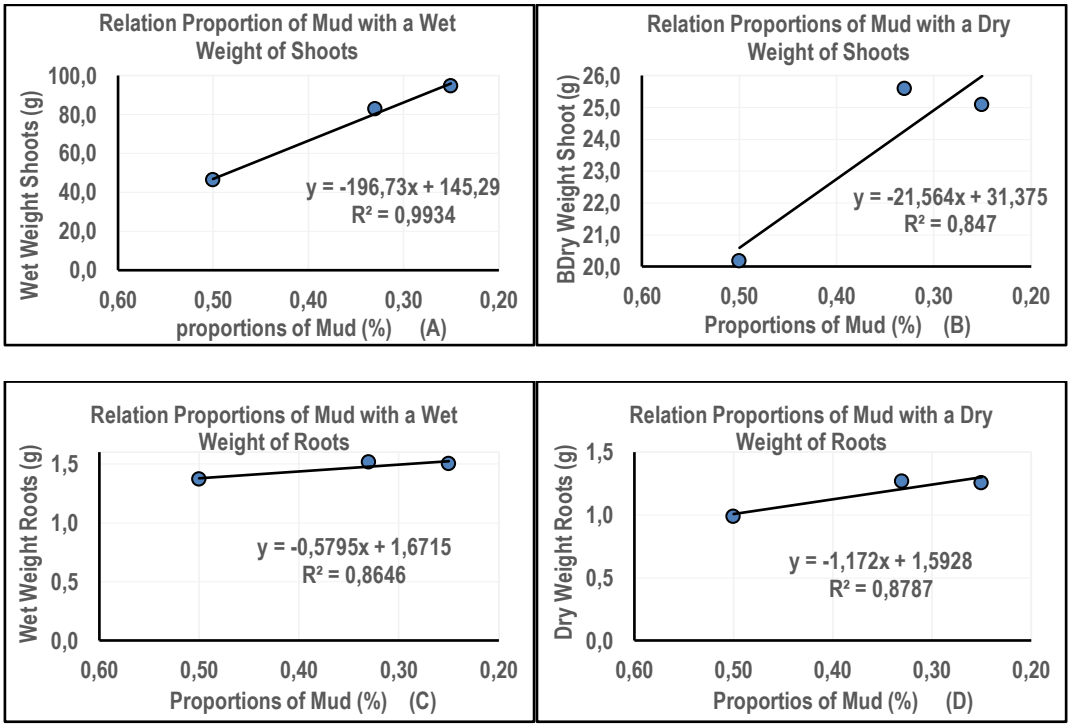

Figure 5. Relationship Proportion of Mud-Land on Wet Weight, Dry Weight of Maize Age 5 WAP.

The above picture illustrates a decrease in the mud of the unit up to 25% showed an increase in weight of wet plant (shoot) at 196,73 units with a coefficient of r = 0,99 (Fig. 5A), plant dry weight increased by 21,56 units with a coefficient of r = 0,92 (Fig. 5B). Whereas wet weight of the root (root) and root dry weight increased respectively by 0,58 units with a correlation of r = 0,93 (Fig. 5C) and 1,17 unit with a correlation of r = 0,94 (Fig. 5D).

CONCLUSION

Based on the analysis of variance parameters expected from the treatment proportion of mud-soil 50%, 33% and 25% given manure 30 ton.ha^{-1} and 50 ton.ha^{-1} and plus gypsum 4 ton.ha^{-1} and 8 ton.ha^{-1} after 5 weeks after planting (WAP), we can conclude the following matters:

1. Total Ferrum plant in the proportion of mud-soil treatment given organic matter and gypsum between 14,76 -21,88 ppm Fe, and an average of 19,56 ppm Fe.
2. The addition of mineral soil portion on the Lapindo mud up to 75% can increase the total Ferrum plant at 5,98 units with r = 0,37.
3. Average total Plumbum (Pb) combination treatment plants proportion of mud-soil, organic

matter and gypsum by 0,33 ppm Pb which is still below the threshold are allowed in the plant

4. Wet weight shoot, shoot dry weight, root fresh weight and root dry weight of the corn crop at harvest (5 WAP) respectively for 71,200 g, 23,61 g, 29,03 g and 14,82 g.

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